WEATHER VARIABILITY, INCOME SHOCKS AND SAVINGS OF RURAL HOUSEHOLDS IN PERU

Solomon Aklilu

I. Introduction

There is a considerable uncertainty in the incomes of households whose livelihoods are based on natural resources, such as farmers who face variable crop yields arising from stochastic rainfall. Government policy that deals with income fluctuation is one way of addressing this uncertainty.

However, if farm households can save in "good times" to overcome the "bad times" there may be no efficiency reason for government intervention. On the other hand, farmers in least developed countries (LDCs) may face obstacles so that consumption smoothing through savings may not be feasible. In these countries, for example, credit markets are far from perfect, and imperfect credit markets prevent households from borrowing. Consequently, in this paper, we use two cross sections of income and expenditure data, a time series regional rainfall data, and supplementary cross sectional information set, to see whether households in rural Peru use their savings in periods of low rainfall to smooth out consumption.

A number of research papers have been written on savings or consumption behavior of rural households. Paxson (1992), Musgrove (1979), Bhalla (1980), and Wolpin (1982) have all contributed to the theory in this paper. Ever since Paxson (1992) developed an explicit way of measuring transitory income, analysts can test directly the hypothesis that households use savings to smooth consumption. For rural households, Paxson showed that unfavorable weather conditions caused fluctuations in the transitory part of total income and that their relationship with savings could be measured. Following in these footsteps we use several years of rainfall data to measure the transitory part of total household income in rural Peru and then estimate the Marginal Propensity to Save (MPS) out of the variability in transitory income caused by these rainfall shocks. Rainfall is an exogenous factor that can influence income and this will allow us to compute an unbiased estimate of one of the basic parameters of the permanent income hypothesis, the MPS, using the permanent income model of savings.

In this study, an empirical model of savings based on both the permanent and the transitory incomes as is set out in Paxson (1992) is derived. The empirical results are then presented and interpreted.

II. Derivation of the empirical savings model

The following model and discussion is based on Paxson (1992) and Deaton (1997). A lifetime utility function that is additively separable over time and that has constant-absolute-risk-aversion (CARA) can be represented by a savings equation, which is linear, in permanent and transitory income. One

such example is: $S_{irt} = \alpha_0 + \alpha_1 Y^P_{irt} + \alpha_2 Y^T_{irt} + \alpha_3 VAR_{ir} + \alpha_4 W_{irt} + e_{irt}$.

(1.1)

Where (S_{irt}) is the total household savings. Permanent income (Y^p_{irt}) is defined over a short time horizon, and it is the expected income of households conditioned on the resources and information of the household at the beginning of the period. Transitory income (Y^T_{irt}), on the other hand, is the difference between realized (after income shock if any) and expected income (had there been no shock). The subscript to both variables represent the incomes of household **i** in region **r** at time **t**. The variability of the household's income is captured by a set of variables that measure the variability of regional rainfall. More variable rainfall implies more variable income. This variable does not vary across households within the same region or across survey years and is denoted by VAR_{ir}. The life-cycle stage of the household, which is denoted by W_{irt}, represents the number of household members in different age and sex groups.

The total measured income (Y) is the sum of its transitory and permanent components. According to the permanent income hypothesis, the coefficients α_1 and α_2, the propensity to save out of permanent income and the propensity to save out of transitory income, would approach zero and one respectively. Therefore, if we find evidence that α_1 is less than α_2, i.e., a high portion of the transitory income is saved, the permanent income hypothesis suggests that households are acting so as to smooth their consumption relative to income. Although, at least theoretically, the sign of α_3 is not clear, empirical tests (Paxson, 1992, Deaton 1997) show that it can provide a control for information on whether households with riskier income streams save more on average than those with more stable income.

The estimation of equation (1.1) requires additional assumptions in order to identify the effects of transitory and permanent income, because these variables are unobserved. For example, let us suppose that we substitute $Y^T = Y - Y^P$, so that equation (1.1) can be written as:

(1.2) $$S_{irt} = \alpha_0 + \alpha_2 Y + (\alpha_1 - \alpha_2) Y^P + \alpha_3 VAR_{ir} + \alpha_4 W_{irt} + e_{irt}$$

If transitory income is the residual term, these equations can be estimated from a single cross-section of data, if suitable instruments for permanent income can be found. It may be that the chosen determinants of the permanent income are actually related to permanent income in the survey year when the data used comprises only one or few cross-sections. Various techniques have been used by a number of authors: Musgrove (1978, 1979), used assets and four age groups with four education levels that cover seven cities of three South American countries as an instrument. Bhalla (1979, 1980) used lagged income and average income over the previous years as an instrument to investigate whether poor households in rural India save more and rich households save less, in response to an increase in investment opportunities. Wolpin (1982) for the case of India used long-run average rainfall (that is historical not the current regional average) as an instrument. Furthermore, to compute the estimates

of the basic parameter of Friedman's permanent income hypothesis and the permanent income elasticity of consumption he used the time-series rational expectation representation and the more usual cross-sectional instrumental variable estimation strategy.

We also adopted the following equations that Paxson (1992) employed. These are estimable versions of the permanent income and the transitory income:

(1.3) $$Y_{irt}^{P} = b_t^{P} + b_{0r} + b_1 X_{irt}^{P} + e_{irt}^{P}$$

(1.4) $$Y_{irt}^{T} = b_t^{T} + b_2 X_{rt}^{T} + e_{irt}^{T}$$

In estimating permanent income, X_{irt}^{P} represents a vector of household specific variables that include land-ownership dummies, number of household members and characteristics including 13 age and education level groups. b_{0r} is a vector of fixed region specific variables reflecting such things as locational advantage. b_t^{P} is a time varying intercept that is common to all households, and e_{irt}^{P} is a random error whose expected value is equal to zero.

In equation (1.4), X_{rt}^{T} consists of both the deviations from the average (**stdRj**) and its square values (**Rjsq**) of regional rainfall at a given time, in each of the four seasons.

The quantity of water available increases for downstream regions when there is rain in the upstream regions. We are going to account for downstream run-off for some regions. For more explanation and calculation of downstream run-off consideration refer to Appendix 1D and 1E.

Paxson (1992) did not account for downstream effects. This could be because Thailand is very flat compared to Peru. Instead Paxson (1992) assigns a certain number of rainfall stations for each region and calculates the regional specific rainfall variations using data from those stations.

b_t^{T} is a time varying intercept common to all households, and the expected value of the random error e_{irt}^{T} is equal to zero.

From equations (1.3) and (1.4) and the identity that total income is the sum of transitory and permanent income, we can form the following equation for total income.

$$Y_{irt} = Y_{irt}^{P} + Y_{irt}^{T} = b_t^{P} + b_{0r} + b_t^{T} + b_1 X_{irt}^{P} + b_2 X_t^{T} + e_{irt}^{P} + e_{irt}^{T}$$

(1.5) $$= b_t + b_1 X_{irt}^{P} + b_2 X_t^{T} + e_{irt}$$

Where, $b_t = b_{0r} + b_t^{P} + b_t^{T}$ and $e_{irt} = e_{irt}^{P} + e_{irt}^{T}$

Equations (1.3) and (1.4) can also be substituted into equation (1.1) to form the following unrestricted reduced- form of the savings equation. To derive the required reduced-form equation we start from equation (1.1):

$$S_{irt} = a_0 + a_1 Y_{irt}^{P} + a_2 Y_{irt}^{T} + a_3 VAR_r + a_4 W_{irt} + e_{irt}$$

$$S_{irt} = a_0 + a_1[b_t^{P} + b_{0r} + b_1 X_{irt}^{P} + e_{irt}^{P}] + a_2[b_t^{T} + b_2 X_t^{T} + e_{irt}^{T}]$$

(1.6) $$+ a_3 VAR_r + a_4 W_{irt} + e_{irt}$$

(1.7) $$S_{irt} = [a_0 + a_1(b_t^{P} + b_{0r}) + a_2 b_t^{T}] + a_1 b_1 X_{irt}^{P} + a_2 b_2 X_{irt}^{T}$$

$$+ a_3 VAR_r + a_4 W_{irt} + [e_{irt} + a_1 e_{irt}^{P} + a_2 e_{irt}^{T}]$$

Therefore, the reduced-form equation can be written as:

$$S_{irt} = g_t + g_1 X_{irt}^P + g_2 X_{irt}^T + u_{irt}$$

$$(1.8) \quad g_t = a_0 + a_1[b_t^P + b_{0r}] + a_2 b_t^T$$

Where, $u_{irt} = e_{irt} + a_1 e_{irt}^P + a_2 e_{irt}^T$

$g_1 = a_1 b_1$ and $g_2 = a_2 b_2$.

Notice the reduced-form savings equation doesn't contain VAR_{ir} and W_{irt} because they both are highly correlated with the transitory and permanent components of the model (Paxson, 1992, p.18), therefore, the more they look alike, the more imprecise is the estimate of their relative effects on savings. However, they could be included in the savings equation when we use estimated approximations of the permanent and the transitory incomes.

Notice also from the above equations that if the permanent income hypothesis is true then $a_1 = 0$ must imply that $g_1 = 0$. Moreover, $a_2 = 1$ implies that $g_2 = b_2$, where a_1 and a_2 are marginal propensity to save out of the permanent and the transitory incomes respectively. These two tests imply collectively that transitory rainfall affects savings the same way as it affects income but it must have no effect on consumption. In particular the test that $g_2 = b_2$ implies that the effect of a transitory rainfall shock on savings should be identical to the effect produced on income. To solve the above problem and test our hypotheses we need to:

1. Estimate equations (1.3) and (1.4) the components of the total income equation, and equation (1.8) the reduced form of savings equation.
2. Estimate equation (1.9) the general savings equation by a two-step procedure.

First, we use the estimated results of equation (1.3) and (1.4) and denote estimates of permanent and transitory incomes as $\hat{Y}_{irt}^P$ and $\hat{Y}_{irt}^T$ respectively. Our second step is to regress the following savings equation:

$$(1.9) \quad S_{irt} = \hat{a}_0 + a_1 \hat{Y}_{irt}^P + a_2 \hat{Y}_{irt}^T + a_3 VAR_r + a_4 W_{irt} + a_5 e_{irt} + e_{irt}$$

Where, $e_{irt} = Y_{irt} - (Y_{irt}^P + Y_{irt}^T)$

III. Inflation adjustment and analysis of savings measures

The two major data-sets we are using, that are collected by the help and active participation of the World Bank, cover approximately 98% (Instituto Nacional de Estadistica e Informacion–INEI)) of farm households in Peru. Therefore, the information about income, expenditure and the like, provided in them combined with our definition of permanent income in the short-term horizon, allows us to use at least three types of savings measures (Paxson, 1992, p. 19). Moreover, in these types of data, as any such data from LDCs it is likely that income to be severely under-reported relative to expenditure, resulting in very low savings figures. Therefore, we used inflation adjustments to bring savings figures much closer to national-accounts measures of household savings as reported by the World Bank World Tables (1985, 1986 and 1994).

The first saving measure, SAVE1, is defined as the difference between income

and expenditure on all goods and services. This definition corresponds to the concept of savings used in the national income accounts. The second saving measure, SAVE2, is defined as the difference between income and expenditure on all goods and services excluding consumer durables, such as, vehicles, household and recreational equipments, furniture, clothing, foot wear, and educational expenses. The third and last saving measure, SAVE3, is defined as all purchases minus the sales assets in the month before the survey.

Again, according to Paxson (1992) the saving measures SAVE1, SAVE2 and SAVE3 are monthly values and have to be adjusted for inflation due to the problems mentioned above, using the following technique:

Let X1i be expenditure on all monthly items, and X2i be average monthly expenditure on annual items, also let Yi be the average monthly income. If AdjSAVEi and AvgX1i are adjusted values of saving and average monthly expenditure respectively and saving is generally defined as Yi-X1i-X2i, then AvgX1i = bX1i, where b is the bias or adjustment factor whose value is between 0 and 1. For this value of b adjusted saving will always be greater than unadjusted saving and can be calculated as:

$$AdjSAVEi = SAVEi + (X1i + X2i - bX1i - bX2i) = SAVEi + (1 - b)(X1i + X2i)$$

Where, i = 1, 2, 3

The reason that SAVE3 should also be adjusted is because it is a measure of the change in assets in the month before the survey; therefore, inflation during the survey can affect the relationship between the fraction of income saved as an asset and the total household income. For a complete derivation of the adjustment factor see Paxson (1992). We also used the CPI values provided by INEI in the month before the survey to find the b-value.

IV. Data and summary of results

We use living standards survey data drawn from the year's 1985/86 and 1994 together with some supplementary information from the 1991 Peru Living Standards Survey (PLSS). Detailed information on the demographic composition of households, amounts of income by source, amounts of consumption by expenditure type, including some asset holdings was collected independently. In addition to the two PLSS data sets, 28 years of time-series data on regional rainfall in 18 different regional weather stations was obtained from the United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) National Data Center.

Statistical Institute of Peru (INEI) implemented the collection of the 1985/86 surveys with the technical and financial support of the World Bank and The Central Reserve Bank of Peru. Initially, 5024 households were selected at the national level with 2284 of these households being from rural Peru with the exception of the departments of Ayacucho, Apurimac and Huancavelica, which were considered emergency zones because of terrorist activity. Overall, 94% of the total population of Peru (19.8 million in 1986) lives in the surveyed area. According to the World Bank specification report, the survey was done simultaneously in all selected areas during 12 consecutive months from the middle of July 1985 to the middle of July 1986. The data was

then checked for errors, which lead to some being eliminated for not meeting the minimum requirement. The remaining data are considered good and highly consistent. In addition to the 4.5% average monthly inflation rate, the Consumer Price Index rose by more than 70% during the application of the 1985/86 PLSS.

The work for all stages of the 1991 PLSS was conducted by the Peruvian research enterprise Cuanto S.A., with only the technical and financial assistance of the World Bank. Because of financial limitations, the geographic field of study did not cover the entire national territory. The rural mountain areas, which are historically the most deprived sections of the country, the central mountains, which are recognized as dangerous zones for reasons of terrorist activity, and the forests regions were excluded due to costs. The central urban was excluded for being very close to Metropolitan Lima. The domain of study then included, only the North and the South (urban coast and mountain, and rural mountain), the Center (urban and rural mountain), and Lima (Metropolitan), which in total cover only 70% of the 22 million Peruvian populations in 1991. The use of this information from the 1991 data in our work is very limited.

The fieldwork for the survey was performed during the months of October and November of 1991. The level of political strife of 1991 was greater than what it was when the 1985/86 survey was conducted, but less severe than the environment in 1990. Moreover, in 1991 the monetary unit was changed from Intis to Nuevos Soles. Unlike the 1985/86 surveys, all monetary values of expenses and income are expressed in constant Nuevos Soles from the first week of October in 1991, based on the prices in Metropolitan Lima. Please note here that in October 1991, 1000 Intis was exchanged for one Nuevos Soles and 0.86 Nuevo Soles equaled $1 (one United States dollar).

Just like the 1991 PLSS, the 1994 PLSS was designed and conducted by Cuanto S.A., but both the World Bank and the Interamerican Development Bank now provided the technical and financial support. However, unlike the 1991 PLSS, the 1994 PLSS covered the better part of the country (almost closer to the 1985/86 PLSS). It provides data on 3623 households from all private dwellings and their inhabitants in Peru. The entire sample consists of 3544 dwellings (a dwelling may contain one or more than one households) of which 820 are from Metropolitan Lima, 1380 are from other urban areas and 1344 from rural areas, which resulted in a final sample of 3623 households. We are using data only on those 1338 rural households or 1344 dwellings. Values of aggregate household expenditure and income have been deflated to correct for inflation. During the survey period the national price rose by approximately 3% per annum. Monthly price data, for 16 cities in all regions, was provided by the Peruvian National Statistical Institute (Instituto Nacional de Estadistica e Informacion–INEI). Each price is then deflated relative to its value in Metropolitan Lima in Nuevos Soles of June 1994.

The second type of data includes time-series information on regional rainfall over the period 1973 - 2000 from 18 weather stations or regions throughout the country. The United States Department of Commerce,

NOAA, Environmental Satellite data and Information Service collected it. Weather stations were then matched with the household information to provide regional weather information for each household in the sample.

The two-stage Ordinary Least Square (2SLS) and bootstrap estimation methods are employed on equation (1.9). The two estimates were quite similar and showed negligible differences; therefore, we reported only the latter. For credit constraint purposes, we also needed to use a dummy variable and variables representing to the positive and the negative transitory income shock. Moreover, this will help us see the effect of these different aspects of the transitory income shocks on savings. The results of these estimates are summarized as follows.

Table 1.1 presents comparisons of unadjusted and adjusted savings measures. Mean values are presented for the four different zones in the 18 regions and for the whole country. Average inflation adjustment factors were assigned to both data based on the average monthly inflation rates and the consumer price indices. As one can see from table 1.1, the inflation adjustment has a much higher effect on savings in 1985/86 than in 1994; however, the biases produced by inflation in both years are not trivial.

Table 1.2 shows how the inflation-adjustment changes the savings rate in 1994 for the four income groups. It solidifies the idea and importance of inflation-adjustments, where clearly in the poorest households, the inflation-adjustment increased the savings rate by about double the amount for the richest households in the survey.

Regression estimates of reduced-form income and savings equations (1.5 and 1.8), with downstream run-off consideration, are shown in table 1.3(a). The income equation results indicate that the transitory rainfall variables are jointly significant in the reduced-form income and savings equations. The other striking result is that the landownership variables for all three of the savings measures are insignificant (see Test 2 F-test p-values at the bottom of table 1.3(a)). These two test results do not provide full support for a strong version of the permanent-income hypothesis.

Table 1.4(a) shows the estimates of the restricted savings equation (1.9). The estimate of the MPS out of transitory income (a_2) ranges from 0.41 to 0.88 and the estimate of the MPS out of permanent income (a_1) ranges from 0.19 to 0.31 for all savings measures. This significantly large difference between these two results supports the idea that rural households save a higher percentage of transitory income than nontransitory income. Since SAVE2 is defined as income minus expenditure excluding durables, it treats durable goods as savings, therefore, one can expect to get a greater MPS for SAVE2 than for SAVE1. The result from the analysis is 0.88 for SAVE2, and 0.84 for SAVE1, which is consistent with this prediction. Moreover, the MPS out of permanent income for SAVE3 is the lowest at 0.19. These results are consistent with those in Paxson (1992), which suggest that although all transitory income is saved not all permanent income is consumed.

Since the error term or unexplained income is calculated as $e_{irt} = Y_{irt} - Y_{irt}^{P} - Y_{irt}^{T}$, it contains both transitory and permanent components

of income; therefore, the estimated MPS out of unexplained income is difficult to interpret. However, the coefficients on this error term for the three savings measures should be between a_1 and a_2 and can be used to see the extent to which measurement error affected the two main coefficients with respect to the three savings measures. The MPS due to unexplained income for SAVE1 is 0.49 (which is between 0.27 and 0.85), and for SAVE2 it is 0.51 (between 0.31 and 0.88) but for SAVE3 it is 0.28 (between 0.19 and 0.41), almost half of those two values above. This is consistent not only with there being greater measurement error in SAVE3 but also with the fact that the error coefficient being between the coefficients of the permanent and the transitory income. For the above reason, therefore, it is always important to use explicit measures of transitory income and permanent income separately to test the life-cycle/permanent income models.

From table 1.4(b), of all variables representing VAR_{ir}, only stdR2 is negatively related to all savings measures, on the other hand both R2r, and R2rsq, have, not only a positive relationship to income and all savings measures, but also increase them by a significant positive amount (see table 1.3(a)). R4r tend to increase income by a certain amount (table 1.3(a)) but stdR4 seems (however small) to have a negative relationship with SAVE1 and SAVE2. R1r increases income while depressing savings (table 1.3(a)), however; stdR1 significantly increases SAVE1 and SAVE2 (table 1.4(a)). R3r decrease both income and all savings (table 1.3(a)), including stdR3, which has a negative relationship with SAVE1 and SAVE2. These relationships between variables and estimation results of tables 1.3(a) and table 1.4(a) indicate that household income and savings are affected separately by seasonal rainfall variability. However, the overall effect of rainfall variability seems to have clear and direct effect on income and on savings of households, yet show no clear relationship between income variability and fluctuations in savings simultaneously.

The effect of the life-cycle stages of the household (the age structure and education level) on income and the savings measures is minimal and in most cases very insignificant. All variables except adult1864 depress income and all savings (table 1.4(a)).

Tables 1.5 and 1.6 report estimation results of the savings measures when the transitory income of households is defined as a dummy variable and divided into negative and positive values respectively. We considered this approach for two reasons. First, we wanted to separate the positive and negative transitory shocks and confirm our previous result and solidify our findings. The second and most important reason is for credit constraint purposes. Our results in both tables are consistent to our findings that are reported in table 1.4(a). That is, variability of regional rainfall variables, stdR4 and stdR2 tend to depress savings while stdR3 and stdR1 tend to affect savings positively (tables 1.5 and 1.6). Most of the life-cycle stages of the household variables, except adult1864, tend to affect savings negatively. These confirm and solidify our previous findings that although all permanent income is not saved, all is not consumed either.

V. Conclusions

The results of this paper clearly show that the behaviour of Peruvian farm households towards savings is generally consistent with the permanent income hypothesis. The MPS out of transitory income due to rainfall is significantly greater than zero and in the range of 0.41 to 0.88, implying that households are able to smooth transitory income shocks. These results mean that negative shocks may not have serious welfare effect on Peruvian farmers because they smooth consumption over time. On the other hand, the MPS out of permanent income is small but still greater than zero. Therefore, while not all of the predictions of the PIH are met, the evidence indicates that these households are able to smooth 41 to 88% of their income shocks.

The types of farming and/or livestock activity undertaken by the Peruvian rural population are cash crops at lower altitudes (coffee on the eastern slopes of the Andes) and rural valleys (fruits and vegetables), subsistence farming and livestock at very high altitudes (Laszlo, 2005, p.12). However, more than 98% of rural households surveyed in 1985/86 and about 99% in 1994 reported to have produced two or more of the following crops: coffee, cotton, sugarcane, rice, potatoes, corn, plantains, grapes, oranges and coca (PLSS 1985/86, PLSS 1994). Therefore, we agree with Paxson's (1992) conclusion that if the transitory world price of these products increases or declines it could have a serious welfare effect on Peruvian economy as well as rural savings. For example, transitory decline in world prices of these products may result in a reduction in farm income, which in turn could lead to a large decrease in savings of the farm sector. However, a government tax on export prices of these farm products may have a smaller effect on rural transitory savings, because the tax will have a permanent and direct effect on the prices and not on household savings.

References

Surjit S. Bhalla, "Measurement Errors and the Permanent Income Hypothesis: Evidence From Rural India," *The American Economic Review*, Vol. 69 No. 3, June 1979, 295-307

---------, "The Role of Sources of Income and Investment Opportunities in Rural Savings," *Journal of Development Economics*, Vol. 5, 1978, 259-81

Olivier Jean Blanchard and Stanley Fisher, Lectures on Macroeconomics, (The MIT Press, 1989.)

Lisa A. Cameron and Christopher Worswick, "The Labor Market as a Smoothing Device: Labor Supply Responses to Crop Loss," *Review of Development Economics, Vol. 7 No. 2, 2003 327-341*

Angus Deaton, The Analysis of Household Surveys, A Microeconometric Approach to Development Policy, Published for the World Bank, The Johns Hopkins University Press, Baltimore and London, July 1997.

James Duesenberry, *Income, Saving and the Theory of Consumer Behavior*

(Cambridge, Harvard University Press, 1949.)
Irving Fisher, *The Theory of Interest* (NY, Augustus Kelly, First edition 1930 and the 1961 ed.)
Milton Friedman, *A Theory of the Consumption Function*, (Princeton University Press, 1957.)
---------, "Windfalls, the 'Horizon' and Related Concepts in the Permanent Income Hypothesis," in Carl Christ (ed.), Measurement in Economics: Studies in Mathematical Economics and Econometrics in Memory of Yehuda Grunfeld, (Stanford, Stanford University Press, 1963.)
Kwabena Gyimah-Brempong and Thomas L. Traynor, "Political Instability, Investment and Economic Growth in Sub-Saharan Africa," *Journal of African Economics*, Vol. 8 No. 1 pp. 52-86
Robert E. Hall, "Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence," Journal of Political Economy, 1978, vol. 86, no. 6
William Hamburger, "The Determinants of Aggregate Consumption," *Review of Economic Studies*, 1955, Vol. XXII, No. 57, 23-34
---------, "The Relation of consumption to Wealth and the Wage Rate," *Econometrica*, Vol. XXIII, January 1955, 1-17
J. Maynard Keynes, *The General Theory of Employment, Interest and Money* (NY, Harcourt Brace, 1936)
Anjini Kochar, "Smoothing Consumption By smoothing Income: Hours-of-work Responses to Idiosyncratic Agricultural Shocks in Rural India," *The Review of Economics and Statistics*, February 1999, Vol. 81(1): 50-61
Simon Smith Kuznets, National Income; a Summary of findings, National Bureau of Economic Research, inc., 1946.
Sonia Laszlo, "Self-Employment Earnings: an Empirical analysis of Non-Farm Activities in Rural Peru," *Journal of Development Studies*, 2005, Vol. 41(7): 1247-1287.
Thomas Mayer, Permanent Income, Wealth and Consumption, (Los Angeles, Berkeley 1972)
Franco Modigliani, "Fluctuations in the Savings-Income Ratio: A Problem in Economic Forecasting," Studies in Income and Wealth, Vol. 11 (NY, National Bureau of Economic Research, 1949)
---------, "The Life Cycle Hypothesis of Saving, The Demand for Wealth and The Supply of Capital," *Social Research*, Vol. 33, Summer 1966, 160-217
---------, "The Life Cycle Hypothesis of saving and Inter country Differences in the Saving Ratio," in W. Eltis, M. Scott and J. Wolfe (eds.) Induction, Growth and Trade, Essays in Honor of Sir Roy Harrod (Oxford, Clarendon Press, 1970) 197-225
Franco Modigliani and Robert Ando, "Tests of The Life Cycle Hypothesis of Savings," Oxford University, Institute of Economics and Statistics, Bulletin, Vol. 19, May 1957, 99-124
---------, "The 'Life Cycle' Hypothesis of Saving, " *American Economic Review*, Vol. LII, March 1963, 55-84
Philip Musgrove, "Permanent Household Income and Consumption in Urban



South America," *American Economic Review*, Vol. 69 No. 3, June 1979

Christina H. Paxson, "Using Weather Variability To Estimate the Response of Savings to Transitory Income in Thailand," American Economic Review, Vol. 82 No. 1, March 1992

Kenneth I. Wolpin, "A New Test of the Permanent Income Hypothesis: The Impact of Weather on the Income and Consumption of Farm Households in India," *International Economic Review*Vol. 23 No. 3, October 1982

Peru Living Standards Measurement Survey (PLSS) 1985-86, Basic Information, Poverty and Human Resources Division, The World Bank, December 1993

---------, (PLSS) 1991, Basic Information, Poverty and Human Resources Division, The World Bank, December 1993

---------, (PLSS) 1994, Supplemental Information, Development Research Group Poverty and Human Resources, The World Bank, August 1998.

National Data Centers, U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Environmental Satellite-Data and Information Service. Surface Hourly Abbreviated 6, 12 and 24 Hour Liquid Precipitation Report in Inches and Hundredths on Peruvian Sites. The World Bank World Tables (1985, 1986 and 1994)



Table1.1 Mean values of monthly savings and income measures, 1985/86 and 1994 individual level observations, in the four zones.
(Number of observations = 27,130 in both years)

		SAVE1		SAVE2		SAVE3		
Zones	Observation	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Income
1. Adjustment factor (b) = 98% [1985/86]								
North Western	757	55.10	110.25	62.31	99.03	111.32	1.57	75.50
		(2046)	(4094)	(2318)	(3682)	(613)	(6.25)	(2728)
North Eastern	3401	244.50	247.40	232.30	235.20	421.80	71.50	375.70
		(7126)	(7126)	(7125)	(7124)	(5686)	(567)	(7121)
South	5197	132.16	128.31	164.90	161.03	65.49	10.40	199.84
		(310)	(308)	(243.50)	(239.60)	(28.24)	(30.40)	(1739)
Centre	8493	1084.50	1850.80	1229.10	1807.50	25.14	4.17	14467.67
		(41926)	(71553)	(47515)	(69876)	(82.90)	(18.00)	(55909)
Peru	17848	1020.56	1530.90	765.32	1020.47	71.23	11.38	1022.50
		(47447)	(22120)	(10603)	(14747)	(579.6)	(72.02)	(47475)
2. Adjustment factor (b) = 99% [1994]								
North Western	752	124.50	126.45	150.24	152.20	6.93	8.91	319.60
		(738.40)	(738.70)	(719.70)	(720.95)	(65.44)	(66.01)	(919.84)
North Eastern	2096	-117.95	-111.95	67.00	72.23	5.43	10.66	405.71
		(6083.80)	(6023.41)	(371.11)	(379.92)	(46.75)	(102.00)	(5080.55)
South	2214	-4008.82	-3964.47	-3816.90	-3772.54	8.65	53.01	426.70
		(18156.70)	(17975)	(18152)	(17971)	(65.89)	(1816.60)	(740.14)
Centre	4223	196.00	201.00	213.30	218.30	-21.04	29.20	698.80
		(846.70)	(851.90)	(878.40)	(883.90)	(29.02)	(26.51)	(167.00)
Peru	9285	-888.17	-876.25	-777.53	-765.61	5.27	17.20	304.0
		(84958)	(84108)	(84863)	(84014)	(51.48)	(85.67)	(3027.50)

Note: Numbers in parentheses are standard deviations. Money values are expressed in 1994 Soles, and are weighted using the weights provided by the World Bank and the Statistical Institute of Peru (INEI)

Table 1.2 Average monthly per capita income quartiles and the two adjusted and unadjusted savings measures for 1994.
(Number of observations = 9282)

	SAVE1/Income			SAVE2/Income		
Income quartile	Unadjusted	Adjusted	Difference	Unadjusted	Adjusted	Difference
Less than 645	-0.202	-0.190	0.012	-0.155	-0.142	0.013
Between 645 and 1112	0.103	0.112	0.009	0.143	0.152	0.010
Between 1112 and 4954	0.264	0.271	0.007	0.298	0.305	0.007
Greater than 4954	0.402	0.408	0.006	0.428	0.434	0.007

Note: All income values are in 1994 Soles



Table 1.3(a) Reduced-form equations of income and savings estimates with downstream run-off consideration.
(Number of observations = 3622)

	Income	SAVE1	SAVE2	SAVE3
Variables	Estimate (t)	Estimate (t)	Estimate (t)	Estimate (t)
Intercept	706.673 (5.26)	171.89 (1.95)	182.865 (2.06)	185.934 (1.93)
Regional locational adavantage dummies:				
yr1985	205.902 (2.03)	-29.13 (0.44)	-10.257 (0.15)	92.434 (1.27)
yr1994	322.121 (4.90)	-13.852 (1.12)	-9.335 (0.78)	14.554 (2.97)
yr1991	-63.064 (0.44)	-75.583 (0.81)	-72.527 (0.77)	-53.976 (0.53)
Rainfall Variables:				
R1r	14.087 (3.91)	-2.027 (0.86)	-2.080 (0.87)	-0.085 (0.30)
R1rsq	0.052 (2.86)	-0.006 (0.44)	-0.005 (0.41)	-0.004 (0.28)
R2r	3.399 (1.10)	0.803 (1.44)	0.798 (2.39)	2.209 (1.12)
R2rsq	0.086 (5.70)	0.025 (2.54)	0.026 (2.65)	0.028 (2.56)
R3r	-8.896 (2.39)	-1.949 (0.80)	-2.017 (0.82)	-1.701 (0.64)
R3rsq	-0.052 (3.97)	-0.009 (1.05)	-0.009 (1.10)	-0.002 (0.26)
R4r	10.476 (2.12)	4.479 (1.39)	4.445 (1.73)	6.352 (1.80)
R4rsq	-0.002 (0.33)	-0.004 (1.06)	-0.005 (1.12)	-0.013 (2.91)
Household Composition variables:				
kids06	-22.440 (2.01)	-3.105 (0.43)	-2.044 (0.28)	-24.489 (3.07)
ma712	-18.831 (0.94)	-27.032 (2.06)	-26.468 (2.00)	-13.654 (0.95)
fe712	15.751 (0.81)	7.898 (0.62)	7.603 (0.59)	-13.807 (0.99)
ma1318	22.615 (1.00)	-6.103 (0.41)	-5.661 (0.38)	8.923 (0.55)
fe1318	49.149 (2.31)	11.635 (0.84)	13.504 (2.96)	2.600 (0.17)
ma1864prim	-7.007 (0.64)	7.881 (1.10)	7.834 (1.08)	-14.834 (1.89)
ma1864sec	98.780 (7.57)	31.210 (3.66)	34.142 (3.97)	7.379 (0.79)
ma1864posec	394.546 (14.22)	110.495 (6.08)	128.600 (7.03)	58.458 (2.94)
fe1864prim	-5.295 (0.34)	11.933 (1.18)	11.348 (1.12)	-14.071 (1.28)
fe1864sec	136.000 (8.57)	38.921 (3.75)	44.685 (4.27)	28.355 (2.50)
fe1864posec	472.964 (15.30)	142.324 (7.04)	158.304 (7.77)	59.731 (2.70)
ma65	61.864 (3.67)	13.762 (1.25)	13.990 (1.26)	10.106 (0.84)
fea65	0.833 (0.04)	-3.291 (0.21)	-5.047 (0.32)	-3.146 (0.19)
Landownership dummies:				
rntlnd	-90.754 (1.27)	-8.014 (0.17)	-12.270 (0.26)	20.287 (0.40)
ownlnd	-118.332 (0.40)	-29.753 (0.15)	-37.396 (0.19)	-68.507 (0.32)
R^2:	0.2453	0.0518	0.0621	0.0308
F tests: p-values				
Test 1	0.0000	0.0051	0.0034	0.0000
Test 2	0.3973	0.9723	0.9461	0.8840

Note: Test 1, rainfall significantly affects both income and savings.
Test 2, land ownership is insignificant.



Table 1.3(b) Reduced-form equations of income and savings estimates without downstream run-off consideration.

(Number of observations = 3622)

	Income	SAVE1	SAVE2	SAVE3
Variables	Estimate (t)	Estimate (t)	Estimate (t)	Estimate (t)
Intercept	300.38 (2.09)	215.09 (2.28)	235.85 (2.66)	188.60 (1.82)
Regional locational adavantage dummies:				
yr1985	288.08 (4.21)	-29.961 (-0.67)	-11.842 (-0.26)	60.897 (1.23)
yr1994	310.55 (11.21)	-1.475 (-1.53)	-3.451 (-1.03)	45.451 (4.66)
yr1991	100.17 (1.26)	-9.419 (-0.18)	-4.983 (-0.09)	-49.538 (-0.86)
Rainfall Variables:				
R1r	-1.838 (-0.26)	-3.895 (-0.84)	-4.514 (-0.97)	0.456 (0.09)
R1rsq	0.086 (1.99)	-0.024 (0.86)	0.029 (1.41)	0.005 (0.36)
R2r	-2.715 (-6.21)	-0.655 (-2.28)	-0.637 (-2.20)	-0.148 (-0.47)
R2rsq	0,005 (1.30)	-0.001 (-0.58)	-0.001 (-0.38)	0.001 (0.34)
R3r	-0.230 (-0.17)	-0.477 (-0.54)	-0.483 (-0.54)	-2.333 (-2.39)
R3rsq	-0.002 (-0.40)	0.006 (2.13)	0.006 (2.07)	-0.008 (-2.52)
R4r	4.760 (1.24)	6.217 (2.46)	6.210 (2.44)	9.627 (3.47)
R4rsq	-0.134 (-1.88)	-0.122 (-2.59)	-0.130 (-2.74)	-0.187 (3.62)
Household Composition variables:				
kids06	-8.333 (-0.74)	-2.277 (-0.31)	-1.066 (-0.14)	-23.318 (-2.88)
ma712	-16.375 (-0.82)	-26.900 (-2.05)	-26.386 (-1.99)	-13.726 (-0.95)
fe712	25.695 (1.32)	8.376 (0.66)	8.171 (0.63)	-12.981 (-0.93)
ma1318	27.853 (1.32)	-4.989 (-0.34)	-4.484 (-0.30)	9.712 (0.52)
fe1318	51.779 (2.45)	12.558 (0.90)	14.741 (2.03)	3.286 (0.37)
ma1864prim	9.571 (0.86)	9.128 (1.25)	9.249 (1.26)	13.906 (1.74)
ma1864sec	98.058 (7.55)	31.353 (3.86)	34.319 (3.99)	6.389 (0.68)
ma1864posec	378.64 (13.69)	109.56 (6.03)	127.520 (6.96)	55.790 (2.80)
fe1864prim	7.817 (0.51)	13.549 (1.34)	13.128 (1.28)	-13.521 (-1.22)
fe1864sec	119.74 (7.56)	37.620 (3.61)	43.216 (4.12)	25.598 (2.24)
fe1864posec	472.96 (15.05)	138.65 (6.86)	154.94 (7.60)	60.781 (2.74)
ma65	71.926 (4.28)	14.528 (1.32)	14.912 (1.34)	10.573 (0.87)
fea65	7.947 (0.34)	-3.781 (-0.24)	-5.433 (-0.35)	-4.171 (-0.25)
Landownership dummies:				
rntlnd	-77.016 (-1.09)	-10.302 (0.21)	-14.935 (-0.32)	19.290 (0.38)
ownlnd	-331.13 (-1.44)	-9.782 (-0.06)	8.466 (0.06)	-33.374 (-0.20)
R^2:	0.2536	0.0518	0.0621	0.0308
F tests: p-value				
Test 1	0.0000	0.0166	0.0023	0.0001
Test 2	0.2653	0.7525	0.8617	0.8840

Note: Test 1, rainfall significantly affects both income and savings.
Test 2, land ownership is insignificant.

Table 1.4(a) Estimates of savings equation with downstream run-off consideration
(Number of observations = 3622)

	SAVE1	SAVE2	SAVE3
Variable	Estimates (s.e.)	Estimates (s.e.)	Estimates (s.e.)
$\hat{Y}^P$	0.2670 (0.0288)*	0.3075 (0.0256)*	0.1936 (0.0276)*
$\hat{Y}^T$	0.8461 (0.0828)*	0.8838 (0.07673)*	0.4089 (0.1045)*
$\hat{e}$	0.4878 (0.0437)*	0.5116 (0.0403)*	0.2815 (0.0580)*
W = Life-cycle stages of the household:			
kids06	2.0766 (3.8531)	3.9847 (3.7861)	-17.0424 (5.2686)**
kids712	-8.1268 (5.4108)	-8.0672 (5.2056)	-11.7159 (8.2098)
kids1317	-6.7255 (6.1142)	-7.1028 (5.9046)	-2.2370 (8.4614)
adult1864	7.9163 (3.2883)**	7.5627 (3.1917)**	-13.6327 (4.4678)**
above65	-2.8427 (6.8212)	-5.3041 (6.8742)	-7.1142 (6.1660)
VAR = Variability of regional rainfall:			
stdR1	2.6184 (0.6047)**	2.6042 (0.5719)**	-0.8421 (0.9257)
stdR2	-4.0992 (0.8484)**	-4.3081 (0.8796)**	-1.4423 (1.4158)
stdR3	4.0116 (1.0752)**	4.3087 (1.1048)**	1.9745 (1.8784)
stdR4	-0.5867 (0.6984)	-0.5220 (0.6432)	0.8890 (1.0078)
t - tests:			
Test 1	15.38	16.05	3.80
Test 2	4.46	3.88	11.36

Note: * Significant at the 2% significant level. ** Significant at the 5% level.
Test 1, $a_2 = 1$. Test 2, $a_1 = a_2$.

Table 1.4(b) Estimates of savings equation without downstream run-off consideration.

(Number of observations = 3622)

	SAVE1	SAVE2	SAVE3
Variable	Estimates (s.e.)	Estimates (s.e.)	Estimates (s.e.)
$\hat{Y}^P$	0.2536 (0.0173)*	0.2933 (0.0165)*	0.1765 (0.0258)*
$\hat{Y}^T$	0.6429 (0.0279)*	0.8728 (0.0266)*	0.3915 (0.0416)*
$\hat{e}$	0.4798 (0.0073)*	0.5033 (0.0070)*	0.2786 (0.0109)*
W = Life-cycle stages of the household:			
kids06	4.5558 (4.8507)	6.5499 (4.6340)	-15.7242 (7.2423)
kids712	-5.859 (5.9721)	-5.7107 (5.7054)	-10.6534 (8.9167)
kids1317	-5.2675 (6.6483)	-5.5475 (6.3514)	-1.2032 (9.9264)
adult1864	9.9027 (3.4643)**	9.5965 (3.3096)**	-11.4864 (5.1725)
above65	-0.4255 (6.1659)	-2.9249 (5.8905)	-4.6456 (9.2060)
VAR = Variability of regional rainfall:			
stdR1	2.6028 (0.7472)**	2.3728 (0.7138)**	-0.4563 (1.1156)
stdR2	-1.4460 (0.9792)	-1.4712 (0.8796)	-0.7007 (1.4621)
stdR3	0.0171 (1.1964)	0.1420 (1.1429)	0.5561 (0.0863)**
stdR4	0.7237 (0.5582)	0.8661 (0.5332)	1.3056 (0.0334)**
t - tests:			
Test 1	12.41	12.66	2.86
Test 2	5.45	4.78	12.03

Note: * Significant at the 2% significant level. ** Significant at the 5% level. Test 1, $a_2 = 1$. Test 2, $a_1 = a_2$.

Table 1.5 Estimates of savings when transitory income shock is defined as dummy variable
(Number of observations = 3622)

	SAVE1	SAVE2	SAVE3
Variable	Estimates (s.e.)	Estimates (s.e.)	Estimates (s.e.)
$\hat{Y}^{P}$	0.2792 (0.0231)*	0.3206 (0.0852)*	0.1982 (0.0275)*
D^{T}_{np}	28.551 (3.3992)*	30.142 (3.3054)*	12.711 (2.9642)*
e	0.4502 (0.0414)*	0.4728 (0.0399)*	0.2619 (0.0508)*
W = Life-cycle stages of the household:			
kids06	8.6893 (4.2256)**	10.826 (4.0474)**	-13.6219 (5.7564)**
kids712	-1.8130 (6.0948)	-1.5056 (5.9563)	-8.5494 (4.3606)
kids1317	-7.8462 (6.6949)	-1.5056 (6.7317)	-2.5686 (8.7194)
adult1864	8.0317 (3.5523)**	7.6134 (3.2469)**	-13.3391 (4.6200)**
above65	-2.4550 (7.1671)	7.6134 (7.1054)	-6.5564 (6.3362)
VAR = Variability of regional rainfall:			
stdR1	1.6601 (0.6322)**	1.6214 (6.3631)	-1.3669 (1.0981)
stdR2	-4.3420 (0.9375)**	-4.6212 (0.8889)**	-1.3570 (1.2084)
stdR3	3.6247 (1.1930)**	3.9836 (1.1168)**	1.5183 (1.5592)
stdR4	-1.3988 (0.6813)	-1.4121 (0.6721)	0.6389 (1.1335)

Note: D^{T}_{np} is a dummy variable where it is one if transitory income is positive and zero otherwise.
* Significant at the 2% significant level. ** Significant at the 5% level.

Table 1.6 Estimates of savings when transitory income is defined as positive and negative shocks.
(Number of observations = 3622)

	SAVE1	SAVE2	SAVE3
Variable	Estimates (s.e.)	Estimates (s.e.)	Estimates (s.e.)
$\hat{Y}^P$	0.2696 (0.0289)*	0.3101 (0.0254)*	0.1944 (0.0280)*
$\hat{Y}^T_{neg}$	0.9413 (0.1215)*	0.9812 (0.1167)*	0.4369 (0.1534)*
$\hat{Y}^T_{pos}$	0.7815 (0.0786)*	0.8178 (0.0716)*	0.3899 (0.0976)*
$\hat{e}$	0.4879 (0.0437)*	0.5117 (0.0392)*	0.2815 (0.0575)*
W = Life-cycle stages of the household:			
kids06	2.1872 (3.8698)	4.0977 (3.6623)	-17.0098 (5.2863)**
kids712	-8.0939 (5.4120)	-8.0336 (5.1563)	-11.7062 (8.0852)
kids1317	-6.8135 (6.0836)	-7.1929 (6.0411)	-2.2629 (8.3230)
adult1864	7.4838 (3.2616)**	7.1205 (3.1108)**	-13.7600 (4.4529)**
above65	-3.3177 (6.8527)	-5.7898 (7.1863)	-7.2540 (6.2219)
VAR = Variability of regional rainfall:			
stdR1	2.7221 (0.6034)*	2.7102 (0.5786)*	-0.8115 (0.9111)
stdR2	-4.2107 (0.8408)	-4.4222 (0.8730)	-1.4751 (1.4262)
stdR3	4.2357 (1.0690)**	4.5379 (1.0936)**	2.0405 (1.9447)
stdR4	-0.5186 (0.7021)	-0.4524 (0.6448)	0.9088 (1.0365)

Note: $\hat{Y}^T_{neg} = \hat{Y}^T$ if $\hat{Y}^T$ is less than or equal to zero and $\hat{Y}^T_{pos} = \hat{Y}^T$ if $\hat{Y}^T$ is greater than zero.
* Significant at the 2% significant level. ** Significant at the 5% level.

Appendix 1A Descriptive statistics of household variables
(Number of Households = 3622)

Variable	Mean	S.D.
Tot Income	552.04	475.11
SAVE1	166.35	612.83
SAVE2	199.49	620.82
SAVE3	187.84	662.87
Regional Fixed Effects:		
yr1985	0.20	
yr1991	0.35	
yr1994	0.15	
Region-Specific Rainfall Variables:		
R1r	49.70	30.58
R1rsq	6948.71	7052.43
R2r	-19.18	120.86
R2rsq	7424.29	6714.64
R3r	-24.63	92.83
R3rsq	9221.06	8114.09
R4r	-3.82	25.04
R4rsq	9557.53	9171.90
stdR1r	97.61	22.86
stdR2r	190.74	51.78
stdR3r	130.16	40.42
stdR4r	30.92	17.69
Land Ownership Variables:		
rntlnd	0.03	
ownlnd	0.87	
both	0.16	
Life-Cycle Stages of Household Composition:		
kids06	1.07	
kids712	0.84	
kids1317	0.66	
ma1864	1.92	
fe1864	1.57	
ma65	0.30	
fea65	0.20	
Adult education levels:		
ma1864prim	0.87	
ma1864sec	0.84	
ma1864posec	0.21	
fe1864prim	0.76	
fe1864sec	0.66	
fe1864posec	0.15	

Note: All money values are in 1994 Nuevos Soles, hence the 1985/86 Intis was converted into 1994 Nuevo Sol using some adjustment factors, where one Nuevo Sol equals to1000 Intis in 1991.



Appendix 1B Descriptive statistics of rainfall across regions or rainfall stations
(Number of Stations = number of regions = 18)

Variable	Mean	S.D.	Min.	Max.
mnR1	212.64	35.51	173.42	253.89
mnR2	453.15	68.96	262.07	372.76
mnR3	322.28	52.52	259.70	382.97
mnR4	78.55	13.71	64.00	376.73
stdR1	132.03	7.44	121.53	141.81
stdR2	266.30	7.92	255.08	274.91
stdR3	188.96	5.08	181.60	193.97
stdR4	48.82	2.27	45.27	51.45

Note: All rainfall measures are converted from inches to millimetres.

Appendix 1C Descriptions of variables used for the empirical analysis

Rjrt	The average rainfall of region r in season j of year t.
Rrj	The average rainfall of region r in season j for the past twenty-eight years.
R1	The average rainfall in the first season, from January to March of the twenty-eight years.
R2	The same as above in the second season, for the months from April to June.
R3	The same as above in the third season, for the months from July to September.
R4	The same as above in the last season of the year, for the months from October to December.
stdRjr	The standard deviation of average rainfall in each season for the twenty-eight years.
mnRjr	The mean of the average rainfall in a given season for the twenty-eight years.
R1r	The deviation of R1from its historical mean in 1985/86 and 1994.
R2r	The deviation of R2from its historical mean during the survey years.
R3r	The deviation of R3from its historical mean during the survey years.
R4r	The deviation of R4from its historical mean during the survey years.
Rjrsq	The square of the deviation of seasonal rainfall from its historical mean.
AvgSAVEi	The average monthly saving as defined by SAVEi.
AdjSAVEi	Inflation adjusted saving as defined by SAVEi.
kids06	Number of children under the age of six.
kids712	Number of children between the ages of seven and twelve inclusive.
kids1317	Number of children between the ages of thirteen and seventeen inclusive.
adult1864	Number of adults between eighteen and sixty four inclusive.
above65	Number of people in the household who are sixty-five and above.
mal1864prim	Number of male in this age group with a primary school education.
mal1864sec	Number of male in this age group with a secondary school education.
mal1864posec	Number of male in this age group with a post-secondary school education.
rntlnd	Number of farmers who rented land in the past twelve months.
ownlnd	Number of farmers who have their own land.
fea65	Number of female sixty-five and above.
ma65	Number of male sixty-five and above.
yr1985	Variable that captures locational and seasonal advantage or disadvantage in a given region during the 1985/86 surveys.

Variables **yr1991** and **yr1994** have the same definition for their respective years.

WMO #	The World Meteorological Organization identification number.
PLSS	Peruvian Living Standards Survey data.



Appendix 1D Identification of regions, rainfall stations and zones for downstream run-off considerations

Station/Region WMO #	Name	Zone	Run-off from Region
1 84377	Iquitos	1	None
2 84425	Yurimaguas	1	None
3 84435	Moyobamba	1	2
4 84455	Terapoto	1	2, 3
5 84444	Chachapoyas	2	None
6 84401	Puira	2	None
7 84452	Chiclayo 2	6	
8 84501	Trujillo	2	7
9 84531	Chimbote	3	8
10 84564	Huanuco	3	None
11 84628	Lima-Callao	3	None
12 84658	Puerto Maldonado	3	None
13 84691	Pisco	3	12
14 84686	Cusco	4	None
15 84701	San Juan De Marcona	4	14
16 84745	Juliaca	4	15
17 84752	Arequipa	4	14, 15
18 84782	Tacna	4	16, 17

Note: Zone 1 is the northwestern geographic area consisting regions 1 to 4; Zone 2 is the northeastern geographic area consisting regions 5 to 8; Zone 3 is the Central geographic area consisting regions 9 to 13; and Zone 4 is the Southern geographic area consisting regions 14 to 18.

Appendix 1E Downstream run-off calculations

For some downstream stations, especially those in the coastal area, regional rainfall values were increased to account for a downstream runoff consideration. For example, if R_{ir} is the amount of rain recorded in station r in season i, and k is a station or region directly down to station r, then the amount of rainfall in station k in season i is calculated as:

$$R_{ikr} = 0.75\,R_{ir} + R_{ik}$$

We assume 25% of the rain in region r has been converted into ground water or evaporated. Note also that station k could also be an upstream to yet another downstream station, say j. In this case the amount of rainfall in station j in the same season is calculated as:

$$R_{ijk} = 0.75\,R_{ikr} + R_{ij}$$

Regions or stations affected by this are:

Upstream donors	**Downstream receivers**
Yurimaguas	Moyobamba
Moyabamba	Tarapoto*
Puira	Chiclayo
Chiclayo	Truijillo
Truijillo	Chimbote
Puerto Maldonado	Pisco
Cusco	San Juan
San Juan	Juliaca
Juliaca	Arequipa*
Arequipa	Tacna*

Note: * Runoff from two or more different stations.